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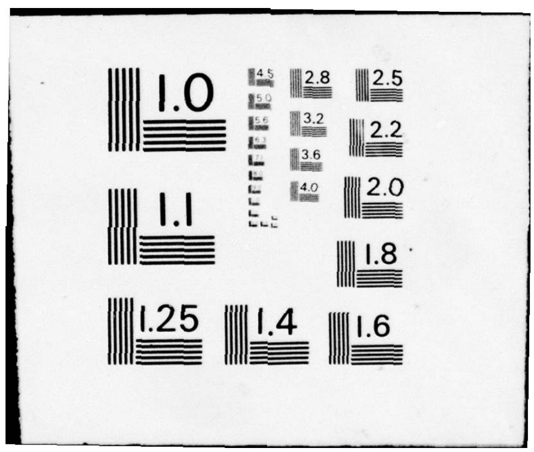
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Wright-Patterson Air Force Base, Ohio

WAR READINESS SPARES KIT COMPOSITION:
A SYSTEMS APPROACH

Charles U. Glazener, Captain, USAF
Alan J. Tinder, Captain, USAF

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WAR READINESS SPARES KIT COMPOSITION:

A SYSTEMS APPROACH

A Thesis

Presented to the Faculty of the School of Systems and Logistics

of the Air Force Institute of Technology

Air University

In Partial Fulfillment of the Requirements for the

Degree of Master of Science in Logistics Management

By

Charles U. Glazener, BA
Captain, USAF

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September 1976

Approved for public release;
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This thesis, written by

Captain Charles U. Glazener

and

Captain Alan J. Tinder

has been accepted by the undersigned on behalf of the faculty of the School of Systems and Logistics in partial fulfillment of the requirements for the degree of

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COMMITTEE CHAIRMAN

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CHAPTER I

INTRODUCTION

Overview

The science of logistics is varied in its nature, encompassing numerous elements that must be interwoven to successfully accomplish military objectives. In official Department of Defense language, logistics is "the science of planning and carrying out the movement and maintenance of forces [22:2]." Expressed in the broadest terms, military logistics can be viewed as the function of providing for needs in peace or war.

During normal or peacetime operations, materiel is maintained either at or near the location where it will eventually be used. Under certain conditions, however, a unit may be separated from the usual stock flow, as in response to mobility requirements. In responding to various contingencies, a unit is required to maintain a combat ready posture under the limitations of being geographically removed from established supply channels. Since the majority of deployments are in response to some type of contingency plan, support for the movements is provided for through the War Reserve Materiel (WRM) program ~~(21:ii)~~. Essentially, the program assures support for operating over

Cont'd

plans through reliance upon materiel that has been accumulated and prepositioned in accordance with preplanned programs and schedules (17:2).

Definition of Terms

Consumption Type Items--those items that are consumed in their entirety; e.g., ammunition, drop tanks, etc., or lose their identity through installation into a next higher assembly; e.g., a generator installed in an aircraft (17:4).

Prepositioned Materiel--War Reserve Materiel consisting of an authorized, predetermined, type and quantity of assets located in the theatre of use prior to the beginning of hostilities to provide support during the initial phase of war pending resupply (17:5).

Prestocked Materiel--War Reserve Materiel composed of assets stocked in the Continental United States at Air Logistics Centers (ALC) to augment prepositioned theatre assets (17:5).

Replacement Type Items--those items that perform a function by themselves; i.e., chairs, tables, test equipment, etc., and retain their identity throughout their life in the military inventory (17:4).

War and Mobilization Plan (WMP)--a continuously revised plan spanning the time period of the USAF Five Year Force and Financial Plan and serving as the source

for current policy, doctrine, concept, and direction for the Air Staff and Air Force commanders concerning the conduct and support of wartime operations (17:2).

War Reserve Materiel (WRM)--extra quantities (in addition to peacetime operating stocks) of supplies which will be needed to support planned wartime operations until production catches up with demand. Such stock includes items essential for the operational effectiveness of combat, combat support, and combat service support forces (18:5).

War Readiness Spares Kit (WRSK)--an air transportable package of selected spares and repair parts required to sustain planned wartime or contingency operations of a weapon system for a specific period of time pending resupply. WRSKs are normally prepositioned with the using unit in order that they are immediately available for the unit's deployment (18:7).

WRSK Level Computation--the process of determining WRSK composition based on failure rates, availability of maintenance support at the proposed base of operations, time change items, turn-around capabilities, and other maintenance data (17:14).

Statement of the Problem

By its very nature, logistics cannot be reduced to an exact science. Constantly changing requirements, budgets, and commitments preclude relying on a given set

of formulas for determining needs. Nevertheless, WRM planners attempt to incorporate patterns of past consumption and operational activities into formulas for determining future requirements (16). Their basic assumption is that future activity will change predominantly in scope and not in character. Obviously, future activities <u>will</u> differ from the past in many more aspects than just scope. Unpredictable combinations of changing combat conditions, broader ranges of possible commitments, and surging demand rates are a few significant unknowns that may affect future needs (17:5). Recent experience has shown that consumption rates varied greatly from projected figures and that WRM was not always used according to design (16).

In particular, the determination of War Readiness Spares Kit (WRSK) composition, with considerations related to future needs under uncertain conditions, presents a problem to the logistics planner. The logistician's resources constrain him, for "prepositioning and prestocking War Reserve Materiel in the range and scope necessary to cope with every possible combination of circumstances would bankrupt the country [17:7]." As a planner, he must determine just how WRSKs should be devised to provide the greatest mobility, flexibility, and application under a wide range of options. Are the present policies adequate for determining WRSK composition? Are WRSKs designed to provide maximum support for a given cost? The answers

to these questions are fundamental to an analysis of the WRSK concept and to the development of a means to determine optimal WRSK composition.

Historical Development

In its report on logistics support to U.S. Forces in Vietnam, the Joint Logistics Review Board commented on the origins of the WRM concept:

> The United States was unprepared for the commencement of hostilities in World War II, mainly because of the time-distance factor separating the United States from potential enemies and our national policy of avoiding foreign entanglements. To buy time to build an industrial base, it was necessary to curtail operations until supplies and equipment became available. The reduced time-distance factor and the international political situation at the close of World War II indicated to prudent military planners the necessity to formally establish, and maintain in peacetime, stocks of materiel to support combat operations until the national production base could be activated [18:7].

The basic concept of WRM has remained essentially the same over the past thirty years. As early as 1946 the necessity for plans providing for the deployment of bulk supply and equipment and a thirty-day maintenance capability was recognized (13:35). Two years later the Strategic Air Command initiated a Mobility and Supply Plan for use when its units were deployed. The unique feature of the plan was the flyaway kit, which was defined as

> . . . that combination of aircraft and communications spare parts which would enable an aircraft to operate thirty days at a prepared advance base without any logistical support from other resources; in other words, a sort of airborne base supply [18:8].

Two important concepts evolved from the early formulation of WRM policy. A thirty-day time frame for support of operations was established, as well as the necessity of establishing priority for WRM. The former has remained as an important determinant of WRM composition for thirty years, while the latter has been somewhat de-emphasized in favor of technical inspection criteria, materiel maintenance, and systematically rated capabilities--factors concerned with examining outputs rather than evaluating inputs (3:13-15).

Literature dealing with WRM composition is scarce, and that which exists is predominantly concerned with how to deal with existing WRM stockpiles as opposed to how to effectively determine WRM composition (7:9; 9:1). This situation might be expected since the determination of logistics requirements has always been a difficult task, wherein planners are faced with changing inputs, budget restraints, and historical planning factors. For example, the Vietnam conflict provides evidence that

> The difficulty in establishing credible logistic requirements stems not only from constant changes in the planning matrix, but also, and more importantly, from the magnitude of and the lack of stability in gross requirements to support all contingency plans. Hard core requirements tend to be obscured by relatively soft total requirements. To correct this situation, certain plans should be designed and utilized as the basis for determination of hard-core logistic requirements [23:28].

WRM requirements are directly related to future needs, but have generated a certain amount of speculation

based on past consumption. Goldstein, in a 1970 study of logistics planning factors, questioned the validity of projections based on past experience (7:9). Too often, he asserted, final output is determined solely on previous data. The use of historical planning factors increases the danger of using the wrong predictor, or basing future action on past experience that may have been atypical. Planning factors also weaken with time, for the more recent the event, the more relevant the experience (12:96-97). Trapp, in a study of War Reserve Materiel written in March, 1975, further emphasized the inherent dangers of relying too heavily on past performance:

> Determining requirements for war consumables encounters all of the familiar difficulties and challenges involved with the translation of the consumption patterns and variable combat activities of the past into valid factors for the future [17:5].

In a 1967 study of WRM, Davis pointed out a continuing need to maintain the status of WRM on a worldwide basis (3:11). To accomplish such an objective, he concluded, "We must have reliable and current asset data from which to make sound appraisals of our support system [3:12]." Such a reporting system, however, can be only as accurate as the initial requirements determination process itself.

Reviewed literature reflected other attempts to improve the WRM program. In 1964 the M-rating System was devised in an attempt to evaluate the effectiveness of

selected WRM assets to meet combat requirements as established in wartime planning documents (3:13). However, such a system evaluates only capability and does not consider the issues of efficiency or cost.

An earlier TIG Brief reminded commanders of the importance of proper maintenance of WRM, pointing out that in an emergency "There is little time to requisition or repair items needed to execute an important mission [9:1]." An audit of eighty-seven bases in twelve commands had revealed deficiencies in serviceables, improperly marked materiels, etc. Once again, emphasis was placed on the outputs rather than the inputs.

Several theses in recent years have examined various aspects of WRM. In 1966, Goldstein and Wilcox developed a cost effectiveness analysis comparing prepositioning and airlift as alternate means of supporting a tactical deployment (7:91). Each alternative was considered in dispersal of WRM, but only after its composition had been determined. The process by which WRM was selected affects materiel quantities and thereby affects the means by which it is distributed (7:3-4).

In 1975, Morrison and Probst researched the requirements aspects in a thesis concerning the mechanized computation of USAF WRM Spare Kits Candidate List (10:72-75). They recommended a joint review of Air Force WRM criteria and suggested the need for investigation into the

feasibility of developing, within current data systems, a comprehensive and reliable means of identifying "all reparable and expendable items which are used on a particular weapon system [10:73]." A study of the second area, that of updating WRM information systems, is currently being conducted by Carlson and Talbott (2:11). However, these two theses (Morrison and Probst, and Carlson and Talbott) deal with WRM after the composition has been determined.

Policy Guidelines--WRM

Much of the official Air Force literature is limited to assigning responsibilities for the WRM program, listing formal reporting procedures and providing general criteria for item selection. The primary planning document for WRM is the War and Mobilization Plan.

> The WRM program basically states that wartime support needs of the Air Force are provided through use of peacetime stock plus WRM which reflects the amount of materiel needed to move from relatively low peacetime consumption rates to higher wartime rates. The basis for estimating the change in rates is constrained in the USAF War and Mobilization Plan (WMP) [17:2].

In particular, WMP-5 (War Consumable Factors and Requirements) puts forth the factors to be considered in planning for materiel usage under wartime conditions. These considerations, as well as the WMP-4 (Wartime Aircraft Activity) provisions dealing with use of bases in wartime, establish the basis for logistics support

documents. These documents provide the necessary criteria for prepositioning and forecasting the need for WRM during planning periods (17:3). Theoretically, the size of the WRM stockpile is large enough to provide combat support until the nation's industrial capability is able to produce at a rate which will be sufficient to keep up with consumption (18:5).

As mentioned previously, the objective of the WRM program is to "acquire, preposition, and maintain in a serviceable condition WRM to support wartime activities in WMP [18:6]." Additionally, policy and responsibilities for the authorization, stockage objectives, location, distribution, accounting, and management of WRM are contained in AFR 400-24.

AFM 67-1 further expands on the responsibilities in AFR 400-24 and

> . . . provides a uniform system for the requisitioning, shipment, issue, assembly, accounting, storage, inspection, maintenance, replacement, redistribution, and adjustment or establishment and requirements of WRM [20:14-5].

The provisions of AFM 67-1 are based on the major objectives of the WRM program, supporting national strategy as directed by the Office of the Secretary of Defense.

> Specifically, the AF objective is to authorize, acquire on time, preposition, prestock and maintain in a serviceable condition, ready for use, all WRM needed to support the wartime activities specified in the WMP [20:14-6].

War Readiness Spares Kits (WRSK)

A specific area of interest in the consideration of WRM is that of WRSK. As a segment of total WRM, the kits are authorized for units which have a weapon, support, or mobile command and control system (18:7). Normally, prepositioned with the using unit, an aircraft squadron's kit consists of replacement spares for use during periods of wartime activity when maintenance is carried out under a "remove and replace" concept. That is, parts which fail are removed from the aircraft and replaced with parts from the kit. Current Air Force policy dictates kits designed to support thirty days of wartime operations (18:8).

One of the earliest studies to evaluate the composition of WRSK was conducted by the RAND Corporation in 1966. RAND developed a model to compute the kits' composition for the Air Defense Command's (ADC) use at their dispersal sites (1:1). A second study was completed in 1968 by RAND for the purpose of designing a model to compute WRSK requirements for the Air National Guard (ANG) (1:1). The models for ADC and ANG differed in that the ANG operated under a fight in place concept, while ADC employed dispersal. ANG, then, was able to supplement war reserve spares with normal day-to-day assets. Both models were designed to optimize aircraft operational rates.

A 1975 Saber Readiness Report[1] detailed the results of a study of the policy and procedures under which WRSKs are provided to those USAF units which are subject to deployment under contingency conditions (18:15). The intent of the research was to examine Air Force policies and procedures in order to determine if methods existed by which the amount of money invested in WRSK could be reduced without lowering the effectiveness of support. The basic alternatives examined included the early deployment of intermediate maintenance, the reduction of average resupply time, and the pooling of WRSKs for the squadrons in a wing into one unit (18:53).

Justification for Research

In an era when budgetary constraints have imposed severe limitations upon resource investments, there is a continued emphasis on examining ways in which current programs can be re-evaluated and made more cost-effective. The dollar value of WRM stockpiles amounted to $3.2 billion as of July, 1975 (2:2), indicating an area in which there is a high potential for savings through increased efficiency. As the costs for new weapon systems have spiraled, the costs of the WRSKs for these systems have also increased. For example, the price tag for an F-15 squadron WRSK is

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[1] The Saber Readiness series of studies is concerned with selected aspects of USAF war readiness. This particular study was undertaken in response to a request by the Deputy Chief of Staff, Systems and Logistics, Hq. USAF.

nearly $31 million compared to approximately $4.1 million for an A-7D squadron (16).

In a personal interview, Mr. C. C. Hively, Chief of Programs Evaluation, Office of Logistics Plans and Programs, AFLC, stated, "The area of WRSK is one of the hottest areas of interest in the WRM program due to the uncertainties and high costs associated with WRSK [8]." Past studies have shown that cost savings are possible. For example, a 1968 RAND study indicated a potential forty percent savings when sensitivity analysis was used to design a kit supplemented by peacetime assets (1:vi). Another study demonstrated that analytical modeling techniques could offer management the ability to incorporate improved methods of managing resources (15:24).

The WRM program is based on procedures that have existed and been perpetuated through habit since 1946 (3:12). The requirements determination process has relied heavily on determining tomorrow's needs on yesterday's usage (16). Stockpiling of unnecessary materiel is costly. Consequently, an investigation into means of improving the WRSK program could have beneficial effects on improving the overall defense effort of the Department of Defense.

Objective

The objective of this thesis is to examine the systems management approach to determining WRSK composition.

This objective is accomplished by formulating a resource allocation model designed to allocate a WRSK budget among the items in the kit in such a way that the total expected number of fills for all items is maximized.

CHAPTER II

RESEARCH METHODOLOGY

Introduction

War Reserve Materiel encompasses a wide and varied range of aspects. In light of the high costs involved with the extensive investment in WRM, there is a continued emphasis on finding more cost-effective methods of determining and acquiring the items for the WRM program. Of particular interest is a means of optimizing resource utilization in the area of War Readiness Spares Kits. The objective of this research is to examine a concept of improving the design of WRSKs and consequently a more efficient use of assets to support wartime operations. An analytical model is used to examine an alternate means of constructing WRSKs and comparing its costs with the cost of current WRSK composition policy.

The Universe Under Consideration

As discussed earlier, WRM includes materiel which has been collected prior to the time of intended use and prepositioned in accordance with prescribed programs and schedules. The WRM program provides for the eventuality when wartime requirements of the Air Force will be provided for through the use of peacetime stock plus WRM. In

general, War Reserve Materiel reflects the anticipated amount of materiel needed to change from lower peacetime consumption rates to higher wartime rates. Within the context of this research, the universe under consideration includes the three general classes of materiel which make up WRM:

1. The first class includes items designated for use in combat operations; i.e., ammunition, drop tanks, petroleum, and other related items sometimes referred to as "war consumables" (17:4).

2. The second class of materiel is comprised of items whose consumption rises sharply under combat conditions; i.e., aircraft spare parts, hardware, and many reparable type items directly used in combat or combat supported actions (17:4).

3. The final category of WRM includes equipment items which have to be readily available to meet the initial surge of demand when shifting from peacetime to full combat status. These items are prepositioned and prestocked to be available for timely utilization (17:4).

The Population of Interest

War Readiness Spares Kits fall into the category of WRM whose item consumption rises greatly under combat conditions. As an integral part of the total WRM, WRSKs are authorized for specific units which have a weapon,

support, or mobile command and control system, "and which are tasked in the USAF WMP for inter-theater deployment with subsequent employment operations prior to D plus 30 days [18:7]." WRSKs are normally prepositioned with the using unit and consist of those spares to be used during a "remove and replace" maintenance concept. The kits are intended to provide supply support for thirty days. The population of interest includes all War Readiness Spares Kits.

The Sample of Interest

For the purpose of evaluating various policies affecting WRSK composition and costs, A-7D WRSKs are used as the sample. The current A-7D WRSK contains 238 line items. The quantity per line item ranges from 1 to 24, and the dollar value of this kit is $4,153,549 (18:18).

The use of the A-7D WRSK is a sample of convenience. Although the results derived from the model during this research depend upon the input data obtained from a specific weapon system, the results are not, in any way, an indication that the model is system dependent. The model evaluated is a model of an inventory system which is used by all weapon systems; consequently, the findings of this research effort can be generalized to all WRSK in the population.

Research Design: Introduction

This research uses mathematical approaches similar to earlier work on base stockage models and design of War Reserve Spares Kits. In this model the function of normal operating assets is considered in the supplementing of WRSKs. The model is used to solve the following type of optimization problem: find the WRSK composition that maximizes expected fills as the measure of the level of protection the kit is to provide subject to a budget constraint.

An essential feature of this research is the systems approach used in evaluating WRSK composition. This method provides significant advantages over the traditional item approach currently used to determine the makeup of WRSK. Item analysis provides allocation decisions which do not consider a specific system objective, but rather an objective for each item. Because of this, the item approach can not measure what happens to the total system when a change is made; i.e., the effect of a change in the stock level of an item upon the fill rate of the system. In conjunction with this deficiency, the amount of investment required to attain a specified level of supply performance is not addressed by item analysis.

The research design used in this model is based upon techniques used in RAND reports authored by Feeney and Sherbrooke (references 4 and 5). Essentially, the method involves the use of the ratio of fill value to

investment cost as a management control variable (5:5). By selecting different control ratios, various levels of system performance and system investment can be realized. Each of these alternative levels will provide maximum system performance for the associated system investment.

The authors state that the major advantages of their techniques are that it shows what level of system performance can be achieved for a given budget and provides a standard against which actual performance can be measured. This approach is also a means of keeping a system within a desired budget and can be used to justify budget requirements by displaying the effects that changes in budget have upon total system performance. Similarly, the control ratio can be used as a management tool to strive for equilibrium in the face of changing demands on the system (4:32).

Along with the emphasis on systems analysis, a more comprehensive approach to demand analysis can be used in determining stockage policies. Traditionally demand analysis considered the past issue rate of an item (demand observed over some past period divided by the length of the period) and assumed that future demand would be close to that level. However, such an approach is appropriate only if adequate past demand history is available. Many items, particularly low demand, high cost items do not possess the necessary requirements for such analysis (5:10).

An approach to demand analysis based on Bayesian Inference has been developed to take advantage of system interrelationships (5). By analyzing the behavior of all items in the system, several significant advantages are realized. The likelihood has been decreased of overestimating demand and buying too much because of a random surge in demand or buying too little because of a random decline in demand. Secondly, use of Bayesian Inference eliminates many of the policy problems encountered with items possessing low demand or unstable demand patterns (5:10). Although explicit use of this technique is not used in this research, the influence of Bayesian Inference is manifested in the research material extracted from the various RAND reports and its inclusion in the model presented here is straightforward.

The argument for the systems approach in this research is clear.

> . . . supply operations are complex systems involving interrelated decisions on thousands of line items. In fact, supply management is system management in the fullest sense. <u>System analysis</u>, the study of the relationship between the behavior of a system and the behavior of its parts, presents significant, new opportunities for profitable innovation in supply management [5:1].

Measures of Supply Performance

Numerous performance criteria exist for the purpose of measuring the effectiveness of materiel stockage policies. In general, emphasis is placed upon the consequences

of not having an item available when it is needed. Any demand that cannot be met from stock on hand is considered to be in a backorder condition. Several of the relevant measures of item supply performance are defined below. Each is a function of the total supply level of spare stock.

1. Ready rate is the probability that an item observed at a random point in time has no backorders.

2. Backorders refers to the number of demands which cannot be satisfied from stock on hand.

3. Operational rate is the probability that no item in the system has a backorder at a random point of time.

4. Fills is a measure of the expected number of units demanded per time period for an item that can be filled immediately from stock on hand.

Each of the definitions is standard throughout stockage policy terminology. For the sake of consistency, the wording of the definitions is that used by Feeney and Sherbrooke (4). Each of the system-performance measures is obtained as the sum of the item-performance measures. Previous research shows that any of the four performance criteria will lead to stock levels that are nearly optimal with respect to the other three criteria when computed under similar conditions (4:18).

For the purposes of this research, the criterion of expected fills is the most applicable. Due to the nature of the situation being considered; i.e., the ability of a War Reserve Spares Kit to meet immediate demands, the criteria dealing with backorders do not provide the desired relevant measure. Furthermore, fills is the most familiar performance measure to the Air Force and is relatively easy to measure (4:18).

Research Hypothesis

The systems approach to resource management results in an improved WRSK support posture relative to that provided by present policy. Furthermore, the systems approach provides decision makers the capability to make cost-effectiveness tradeoff analyses on the composition of the mobility kits as budget authorizations change.

Present WRSK Policy

Quantities currently in the WRSK are determined by multiplying the expected number of flying hours by the item demand rate and by the quantity needed per aircraft, producing the expected number of demands during the thirty-day period. This computation also takes into account past experience of weapon system managers, the using activities, and the manufacturer. The various data elements used in the computations are extracted from the AFLC D041 system.

WRSKs are designed to support a deployed squadron for a period of thirty days without resupply (18:142).

Model Design

The model used in this research has as its primary objective the maximization of the sum of expected fills for all items in a War Reserve Spares Kit subject to a budget constraint. In designing the model, two significant assumptions were considered. First, resupply is not being used to improve the supply performance of the WRSK; hence, the model considers only the operating location and is, as a result, a single-echelon inventory model. Second, demand is assumed to be described by a simple Poisson distribution rather than a compound Poisson distribution. The compound distribution is appropriate when sympathetic removals are considered, or when the probability of compound failures is high. This assumption tends to bias the model to a small degree, but it is assumed that this bias will be offset by the effects of attrition of aircraft during battle.

The desired objective is to maximize the sum of expected fills, which can be stated symbolically as:

$$\text{maximize} \sum_{j=1}^{N} F_j(s_j)$$

subject to the system (kit) budget constraint,

$$\sum_{j=1}^{N} c_j s_j \leq C_T \ ,$$

where

s_j = stock level of item j,

c_j = unit cost of item j,

C_T = total budget limit for the kit,

N = total number of different items in the kit, and

$F_j(s_j)$ = expected fills for item j when s_j units are in the kit.

If $p(x_j|\lambda_j)$ is the probability of observing x_j demands for item j when its mean demand is λ_j for the support period, then the expected fills for item j can be written as:

$$F_j(s_j) = \sum_{x_j=0}^{s_j-1} x_j p(x_j|\lambda_j) + s_j \sum_{x_j=s_j}^{\infty} p(x_j|\lambda_j)$$

This problem is an integer, nonlinear programming problem and can be solved easily by noting that the first forward differences of the $F_j(s_j)$ are monotonically decreasing and are given by:

$$F_j(s_j+1) - F_j(s_j) = 1 - \sum_{x_j=0}^{s_j} p(x_j|\lambda_j).$$

The Lagrangian version of this problem is:

$$\text{Max} \sum_{j=1}^{N} \{F_j(s_j) - \theta c_j s_j\} = \sum_{j=1}^{N} \text{Max} \{F_j(s_j) - \theta c_j s_j\} ,$$

where θ is the Lagrange multiplier (ratio of expected fills to investment).

This problem is separable and, for each item j, the interior problem is solved by finding the largest integer s_j satisfying:

$$F_j(s_j+1) - F_j(s_j) \geq \theta c_j \ .$$

Since the first forward differences of $F_j(s_j)$ are monotonically decreasing, $F_j(s_j)$ is concave in s_j and the maximum value of the objective function is unique.

Algorithm for Maximizing Expected Fills

The solution to the problem introduced in the Model Design section is reduced to a one dimensional search for θ^*, since the optimal value of θ will determine the optimal s_j values. Fox and Landi (6) describe a method which bounds θ^*; but experience has shown that this approximation technique can be troublesome (11). Since each value of θ defines an optimal allocation for some budget value, it is more meaningful to use θ as a management control variable as suggested by Sherbrooke (5).

By allowing θ to vary between zero and some upper limit, a cost-effectiveness curve can be generated which illustrates the relationship between supply performance and investment in the kit.

The following set of steps describes the algorithm used to develop the cost-effectiveness curve:

1. Set θ equal to the reciprocal of the largest unit cost in the kit.

2. For each item j, find the s_j maximizing $F_j(s_j) - \theta c_j s_j$ and compute the kit investment.

3. Vary θ and repeat steps 1 and 2. (Note: increasing θ will decrease the investment and vice versa.)

Data Base, Collection, and Validity

AFLCM 57-3 (Recoverable Consumption Item Requirements System [D041]) provides guidance for the computation of expendable investment recoverable spares (19:1-1). The data collected through its detailed procedures reflect the average materiel support requirements for Air Force operations. Procedures, forms, computation worksheets, and backup data developed in the process constitute the official record to substantiate the procurement program and other logistics action. An automated, centralized file of item data has been established for use by AFLC Headquarters, and is designed to accomplish, among other things, the following:

(a) Perform the routine clerical, mathematical, and statistical workload involved in computing recoverable item requirements.

(b) Forecast gross and net requirements using past and future programs, usage history, and asset information maintained within this system (19:2-1).

(c) Serve as a source of current input data for use in problem solution, simulation studies, and other management decisions (19:1:36).

The data bank includes, for example, budget codes, base repair cycle, depot repair cycle, order and ship time, failure rates, base repair rates, and reparable generations for past and future programs from which was extracted the required data for each line item of the A-7D WRSK. The data were catalogued by product number and can be accessed via the CREATE system (19:2-3). The required failure, repair, and probability rates of each of the 238 line items was collected and grouped by item for application to the model.

Failure, replacement, condemnation and other reliability or maintainability rates are developed on the basis of past usage and program data accumulated over a standard time period. The time period is referred to as the base period and is normally the last twenty-four months (19:1-4). Therefore, the data collected for this analysis consists of <u>all</u> failure rates, repair times, etc. that have been recorded, compiled, and computed for each item of interest during the most recent two-year period. Since all of the items in the A-7D WRSK have been in the inventory

for more than two years, the D041 data bank reflects, in the long run, a sample of convenience of failure, repair, shipping, etc. rates. That is, the data representing such rates for the history of each WRSK item have been lost to the system, and reliance for valid data is made on the two-year sample of convenience.

The basic assumption related to the use of D041 data is that it reflects accurate maintenance and reliability rates. This assumption can be justified by a brief explanation of the quality control system functioning within the AFLC requirements system. The Directorate of Materiel Management item manager (IM) is responsible for maintaining current and valid data for assigned items (19:5-1). This responsibility includes the surveillance of data provided by source systems, the preparation of appropriate file maintenance forms, the review of output products provided by the system (D041), and actions indicated by these system products. Each IM is directed to exercise "extreme care to insure the accuracy of data input to the requirements computation process [19:1-36]." For example, the Depot Repair Cycle Management System (G068) furnishes quarterly information to the IM for review and comparison between the actual repair cycle number of days and the number of days used in D041 computation (19:1-7). Data are provided as a tool for use in determining whether to update the depot repair cycle in

the requirement file, or take other action. Similarly, each Air Logistics Center (ALC) is directed to take all appropriate actions to insure the establishment and maintenance of effective local controls over input to the requirements computation.

The validity of the data is also strengthened and kept current through a detailed process which includes the following (19:5-1):

(a) Assets and usage data are maintained by current stock number. Only records with significant data are maintained.

(b) A twenty-four months item past program history record is maintained for each item application. Three months of new data are generated quarterly and the oldest three months of data are dropped.

(c) Factors used in the computation of requirements are either computed or maintained from manually prepared transactions during each file maintenance process.

As a final verification of D041 data, error lists reflecting various data elements which do not conform to specified standards established by AFLC are output from the data bank. These stock number listings are provided to the individual item managers of each ALC, who review them and take the necessary action to correct any erroneous data (19:1-36). These actions are considered

essential as a means of improving the quality of requirements within the D041 system.

Testing the Hypothesis

The research hypothesis has been stated as: the systems approach is a more effective means of determining WRSK composition than current policy. To test this hypothesis, an analytical model is used to evaluate present WRSK policy in terms of the level of expected fills (or system fill rate) it provides. If the method developed here provides a higher level of support for the same investment than is obtained by present policy, then the hypothesis will be supported.

Summary List of Assumptions

1. The quantity demanded for an item in a fixed period is assumed to follow a stationary probability distribution. In particular, the form of the assumed distribution is Poisson.

2. The quantity demanded for an item is independent of other items. This assumption is valid as long as there are not many complex relations among replaceable items.

3. The wartime demand does not depend on the number of serviceables that might be available from day-to-day operating stocks.

4. Items to be considered for inclusion in the kits are equally essential for all missions.

5. Lateral resupply of items will not be employed.

6. Sortie capability of a deployed squadron will be proportional to the number of operationally ready aircraft.

7. Cannibalization of aircraft parts will not be considered.

8. Installed items will fail at random.

9. Items will fail independently of each other.

Summary List of Limitations

1. The results of this research are applicable to all mobility operations for the period of activity prior to the establishment of a resupply capability.

2. As with any analytic model, the accuracy of the results are limited by the accuracy of the forecasted values of the input parameters.

CHAPTER III

RESEARCH APPROACH

Introduction

The A-7D WRSK was the kit selected for evaluation. A listing of the items in the current A-7D WRSK was obtained from a Saber Readiness Report (18:120-125) and is presented in Appendix A. A sortie duration of 2.5 hours was used for each of twenty-four-unit equipment aircraft over the thirty-day deployment period.

Determination and evaluation of the fill rate of various WRSK compositions was accomplished. The model used for maximizing expected fills is found in Appendix B. Another program was constructed for determining the fill rate of the current A-7D WRSK. This program is found in Appendix C.

The objective of the model used in this research was the maximization of expected fills based on the maintenance data on A-7D WRSK items obtained from the D041 system. The results from the model are found in Appendix D.

Evaluation of A-7D WRSK

To establish a starting point, or base case, upon which to begin analysis, the current A-7D WRSK was

evaluated to determine its fill rate. The present kit, consisting of 238 line items, ranging from one to twenty-four in quantity per line item, and costing $4,153,549, yielded a fill rate of 55 percent. This fill rate was based solely on the demand rates indicated in Appendix C. No assumptions such as air resupply, cannibalization, etc., were made. Hence, the current WRSK was evaluated under the worst possible conditions for a thirty-day deployment.

Management-Control Variable

The thrust of the approach used in this research was to account for the system implications of item decisions and to allow for the choice of a system policy that can be implemented at the item level. The choice of an optimum policy would have been a simple matter if the value of a fill were easily determinable. If the item fill value were known, then the solution to the problem of budget allocation would be determined by selecting the stock levels which maximize the net value of the fills provided by that stock. However, the value of a fill is quite subjective for problems involving DOD resources and an alternative technique should be employed.

Rather than attempting to establish an actual ratio of fill value to investment for each item, a desired ratio can be established and used as a management-control variable. In other words, by specifying a value

for this ratio, the model can allocate a budget among all of the items in the kit in such a manner that the ratio of fill value to investment is the same for each item in the kit. This is reasonable if it is assumed that each item in the kit is equally essential to the mission.

Figure 1 depicts the values obtained from the model when it was run to maximize expected fills for the items in the current A-7D WRSK for a thirty-day period.

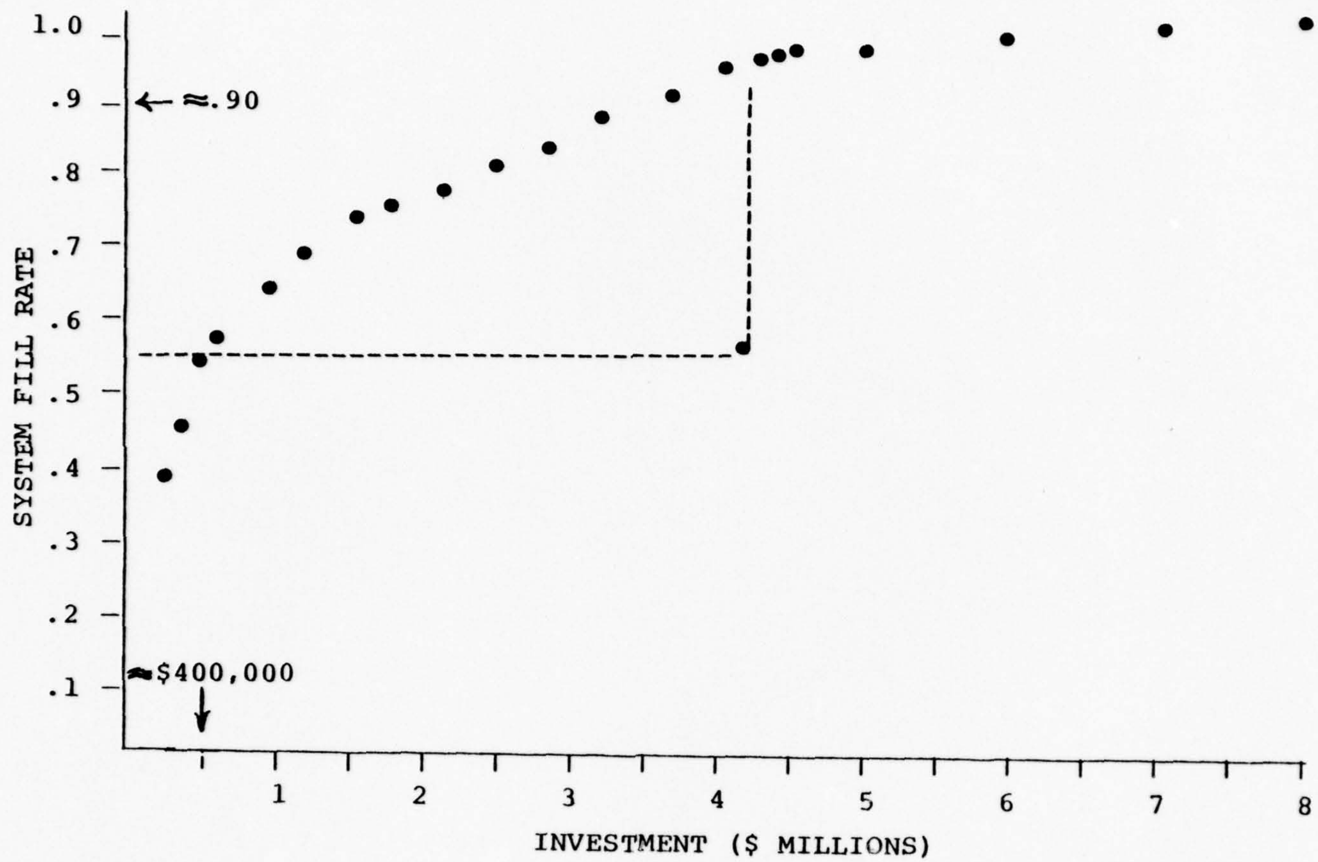

Fig. 1. System Performance versus Investment for A-7D Kit

CHAPTER IV

DATA ANALYSIS, CONCLUSIONS, AND RECOMMENDATIONS

Data Analysis

Computer runs conducted during this research provided data on fill rates and associated budgets under varying conditions. The following figures were extracted to highlight significant results (see Appencices).

Table 1

Examples of Results

Method	Fill Rate	Investment (Millions)
Current Method	.55	4.2
Systems Model	.56	0.5
	.79	2.0
	.90	4.1
	.95	6.0

The above data reveals the disturbing fact that current WRSK policy would not permit a deployed squadron, which has been completely detached from routine supply channels, to perform its mission for the desired thirty-day period. With only 55 percent fill rate, the present system would inevitably ground a large portion of the squadron within a short time.

The current A-7D War Readiness Spares Kit contains at least one of each of the 238 items regardless of the item's unit cost or expected demand rate. An examination of the listing of the line items readily reveals certain inadequacies about the stockage policy used to build the WRSK. For example, from Appendix C, the expected thirty-day demand for item 18 is 17.6 units, yet the quantity stocked is three. Item 113 has an expected demand of 22 units with only three stocked. Likewise, item 33 has an expected demand of 57.6 units, but only 24 are stocked. Numerous other similar shortages exist. On the other hand, many authorized items have an extremely small expected demand rate, yet are nevertheless contained in the kit in what appears to be unwarranted quantities. Item 71 has only a .0018 expected demand rate for thirty days with six units stocked. Many items have less than a .1 demand rate for thirty days, yet the WRSK contains at least one of each of these items, regardless of their unit cost.

A look at the cost associated with achieving different levels of fill rates gives further evidence of the inefficiencies of the current policy. The present WRSK provides a fill rate of 55 percent for 4.2 million dollars, whereas the concept of maximizing expected fills provides a 90 percent fill rate for the same cost (Table 1). Hence for the same level of investment, maximization of fills provides a higher level of performance than current

policy and is therefore more cost-effective as defined in Chapter II under the section Testing the Hypothesis. The alternative way to look at these results is to compare the investments required by the two methods to achieve the same level of performance. Whereas the current method can satisfy 55 percent of the demands for $4.2 million, the method of maximizing expected fills can satisfy 55 percent of the demands for only $400,000.

Conclusions

The systems approach used in this research provided a means of evaluating the effect of stockage decisions upon the total performance of the WRSK. Evaluation of system fill rates showed that WRSKs could be designed to be more effective and efficient than present WRSKs. The method of maximizing expected fills permitted a substantial reduction in cost for the same performance level or a much higher level of support for the cost of current WRSKs.

It appears that the items included in the A-7D WRSK were put into the kit in an arbitrary fashion regardless of cost or expected demand rate. By placing at least one of each authorized item into the kit, mission support has been degraded and a large sum of money invested for a low level of performance. The argument for including each of these authorized items "just in case" is rather tenuous and could be carried to the extreme of carrying one of every

item on the aircraft. Such a policy would be prohibitively costly. As demonstrated by the application of the systems approach, a more effective means of supporting a deployment exists.

An important feature of current WRSK policy is the assumption that aerial resupply will be available on the thirty-first day of the deployment. The data obtained in this research demonstrate the unlikeliness that current WRSK would be able to keep an entire squadron flying while awaiting resupply. An obvious solution to the problem would be resupply on the first day. However, since this is not feasible, WRSK ought to be either designed to provide support for the full thirty days or policy changed to redefine the deployment time span.

Recommendations

In light of the results obtained from this research, the following recommendations are presented:

1. Use a systems approach to determine the effect of stockage decisions on total system performance.

2. Reconsider the thirty-day time period that has been used for years as the standard deployment duration.

3. Consider possible alternatives to improve support performance during the deployment phase.

4. Pursue the possibility of incorporating the concept of maximizing expected fills into the Saber Readiness model.

Summary

As a consequence of the continuing emphasis on the cost-effectiveness of WRSK, the subject of WRSK composition was deemed to be a fertile area for research. To acquire background for the research the history of WRM and WRSKs was revised and the current WRSK policies were examined. The research was conducted in the following manner:

1. The need for the research was established.

2. A case was built for using the systems approach in stockage policy.

3. A mathematical model was developed to maximize expected fills.

4. Two programs were developed to evaluate fill rates.

5. The data generated by the model and the programs were used to show the advantages of constructing WRSKs by using the systems approach, in particular, the maximization of expected fills for the total WRSK.

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AFIT RESEARCH ASSESSMENT

The purpose of this questionnaire is to determine the potential for current and future applications of AFIT thesis research. Please return completed questionnaires to: AFIT/SLGR (Thesis Feedback), Wright-Patterson AFB, Ohio 45433.

1. Did this research contribute to a current Air Force project?

a. Yes b. No

2. Do you believe this research topic is significant enough that it would have been researched (or contracted) by your organization or another agency if AFIT had not researched it?

a. Yes b. No

3. The benefits of AFIT research can often be expressed by the equivalent value that your agency received by virtue of AFIT performing the research. Can you estimate what this research would have cost if it had been accomplished under contract or if it had been done in-house in terms of manpower and/or dollars?

a. Man-years ________ $ ________ (Contract).

b. Man-years ________ $ ________ (In-house).

4. Often it is not possible to attach equivalent dollar values to research, although the results of the research may, in fact, be important. Whether or not you were able to establish an equivalent value for this research (3 above), what is your estimate of its significance?

a. Highly Significant b. Significant c. Slightly Significant d. Of No Significance

5. Comments:

________________________ Name and Grade

________________________ Position

________________________ Organization

________________________ Location

Determining what items to stock in the event of combat poses serious problems for the logistics planner. Stocking one of every item which might be needed would be prohibitively costly. This research was undertaken to examine the current approach to building War Readiness Spares Kits and contrast its level of performance with an alternate means of choosing items for the WRSK. In particular, a systems approach using the concept of maximizing expected fills for the entire kit was incorporated into an analytical model. The results of the research led to the conclusion that the systems approach is a more effective and efficient means of constructing WRSK.

APPENDICES

APPENDIX A

AUTHORIZED LINE ITEMS FOR THE A-7D WRSK

APPENDIX A

Appendix A consists of the following data for each line entry:

Column	Data
1	Computer line number
2	Kit line item number
3	Item name
4	Unit price ($)
5	Repair time (days)
6	Fraction of failures not reparable by intermediate maintenance
7	Failure rates per aircraft hour
8	Quantity per aircraft
9	Quantity authorized in current A-7D kit
10	Quantity proposed in Saber Readiness reduced kit

```
005 1 ENTUNIT 1206 10 42 .000068 1 3 2
010 2 M61GUN 8116 10 37 .000129 1 5 3
015 3 DRIVEU 1041 10 33 .000141 1 6 3
020 4 MOUNT 185 10 0 .000015 1 1 1
025 5 CHUTE 248 10 58 .000306 1 13 7
030 6 CHUTE 165 10 0 .000365 1 15 8
035 7 EXITUNIT 1141 3 14 .000427 1 14 7
040 8 DRUM 313 10 0 .000059 1 2 1
045 9 CTLAY 944 3 73 .000391 1 13 7
050 10 DRIVE 1813 1 82 .000202 1 8 4
055 11 LOADAY 2555 6 40 .001431 1 14 7
060 12 CHUTE 363 1 16 .000486 1 8 4
065 13 TRANSU 2416 5 38 .001186 1 8 4
070 14 LUBR 309 6 57 .000209 1 4 2
075 15 HSNG 990 3 100 .000142 1 6 3
080 16 DRUM 6101 4 15 .000463 1 5 3
085 17 DRIVEAY 493 10 0 .000059 1 3 2
090 18 PACK 1147 1 69 .001632 6 3 2
095 19 ARMCTL 27573 3 42 .001310 1 2 1
100 20 CTLSEL 239 5 100 .000122 1 1 1
115 21 CAPAY 2780 10 63 .000082 1 1 1
120 22 RADOME 2194 10 13 .001897 1 3 2
125 23 RELAY 873 3 3 .002020 2 4 2
130 24 RESTR 490 5 15 .000351 1 1 1
135 25 CABLEAY 255 0 100 .001500 6 4 2
140 26 DUCT 184 2 43 .001113 1 2 1
145 27 STRUTNG 3973 6 25 .000165 1 1 1
150 28 CYLNDR 3751 5 46 .000515 1 1 1
155 29 STRUTAY 1612 10 58 .000340 2 1 1
160 30 VALVE 205 5 0 .000001 1 1 1
165 31 WHEELNLG 437 2 1 .003154 2 6 3
170 32 VALVE 1597 5 77 .000134 1 1 1
175 33 WHEELMG 995 4 5 .016000 2 24 12
180 34 VALVE 257 3 50 .000001 2 1 1
185 35 CONTROL 1681 0 100 .000588 1 1 1
190 36 BRAKEAY 2061 1 81 .001578 2 3 2
195 37 SWVLJT 274 10 20 .000052 1 1 1
200 38 SWVLJT 274 1 50 .000052 1 1 1
205 39 EXTUNIT 83 1 17 .000124 1 1 1
210 40 EXTUNIT 83 4 11 .000558 3 1 1
215 41 EXTUNIT 83 3 21 .000299 1 1 1
220 42 EXTUNIT 90 2 7 .000443 1 1 1
225 43 EXTUNIT 86 3 6 .000340 1 1 1
230 44 VALVE 254 10 0 .000010 1 1 1
235 45 VALVE 226 1 0 .000021 1 1 1
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240 46 VALVE 269 8 0 .000021 1 1 1
245 47 VALVE 309 10 30 .000670 1 1 1
250 48 VALVE 281 10 67 .000910 1 1 1
255 49 ACCUMLTR 1385 4 44 .001000 2 3 2
260 50 CYLAY 738 3 43 .000144 1 1 1
265 51 CYLAY 737 3 44 .000186 1 1 1
270 52 VALVE 150 5 43 .000720 5 3 2
275 53 CYLAY 2471 7 60 .000103 1 1 1
280 54 VLVPRES 122 4 8 .000422 2 1 1
285 55 CSD 13818 10 93 .000289 1 2 1
290 56 VALVE 185 2 75 .000082 1 1 1
295 57 VALVE 284 6 95 .000206 1 1 1
300 58 VALVE 431 6 46 .000124 1 1 1
305 59 SWVLJT 139 1 30 .000104 8 1 1
310 60 ACCUMLTR 392 2 30 .000237 1 1 1
315 61 ACCUMLTR 1633 4 53 .000392 1 2 1
320 62 CYLAY 1165 3 18 .000402 1 1 1
325 63 CYLAY 571 10 100 .000164 4 1 1
330 64 CYLAY 1806 10 85 .000148 4 1 1
335 65 CYL 588 7 50 .000132 2 1 1
340 66 CYL 550 6 38 .000082 2 1 1
345 67 VLVAY 1315 6 27 .000310 2 1 1
350 68 CYL 915 2 20 .000103 1 1 1
355 69 ACTLAY 1553 10 57 .000800 1 1 1
360 70 ACCUMLTR 1360 5 60 .000258 1 1 1
365 71 VALVEAY 14447 1 47 .000175 1 1 1
370 72 ELEMENT 146 3 1 .006165 1 7 4
375 73 CYLNDR 2825 1 71 .000351 1 1 1
380 74 CYLAY 3301 3 74 .000351 1 1 1
385 75 VALVE 1644 10 40 .000071 1 1 1
390 76 VLVAY 1707 2 42 .000124 1 1 1
395 77 VLVAY 1588 4 58 .000124 1 1 1
400 78 CYL 554 3 66 .000361 1 1 1
405 79 ACT 4196 6 40 .001444 2 2 1
410 80 ACT 3792 5 47 .000485 1 1 1
415 81 PUMP 1329 1 93 .000925 1 1 1
420 82 VALVE 158 2 23 .000134 2 1 1
425 83 CYL 1408 3 69 .000774 2 1 1
430 84 CYLAY 1515 3 46 .000134 1 1 1
435 85 CYLNDR 1572 6 33 .000062 1 1 1
440 86 CYLAY 1684 7 75 .000186 1 1 1
445 87 CYLAY 1684 10 100 .000082 1 1 1
450 88 VALVE 76 10 0 .000010 2 1 1
455 89 CYL 713 3 57 .000557 1 1 1
460 90 SWIVEL 162 5 75 .000124 1 1 1
465 91 EXTUNIT 88 2 13 .000700 4 1 1
470 92 EXTUNIT 92 1 15 .000774 2 1 1
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475 93 EXTUNIT 89 7 9 .000113 1 1 1
480 94 EXTUNIT 107 2 21 .000144 2 1 1
485 95 VALVE 84 8 69 .000072 1 1 1
490 96 SWVLJT 151 10 100 .000010 1 1 1
495 97 DAMPEHR 602 1 86 .000515 1 1 1
500 98 VALVE 201 3 50 .000020 2 1 1
505 99 EXTUNIT 91 2 8 .000402 2 1 1
510 100 EXTUNIT 112 1 5 .000474 1 1 1
515 101 EXTUNIT 89 2 0 .000268 4 1 1
520 102 CONVTRLO 469 4 64 .003574 1 6 3
525 103 TURBINE 2462 0 100 .003062 1 5 3
530 104 VALVE 470 3 93 .000278 1 1 1
535 105 VALVE 248 10 87 .000392 1 1 1
540 106 VALVE 788 10 91 .000237 1 2 1
545 107 REGLTR 407 5 95 .000402 1 1 1
550 108 VALVE 485 0 100 .000268 1 1 1
555 109 VLVSNSR 664 4 98 .000258 1 1 1
560 110 PNLCTL 1349 3 47 .001142 1 2 1
565 111 VALVE 210 0 100 .000175 1 1 1
570 112 LOXREG 335 4 71 .000328 1 5 3
575 113 RELAY 156 2 3 .001750 7 3 2
580 114 ACTUATOR 1163 4 88 .000062 1 1 1
585 115 ACT 1524 5 85 .000278 1 1 1
590 116 PANEL 795 5 20 .000244 1 1 1
595 117 ACT 945 1 98 .000495 1 1 1
600 118 REEL 171 10 100 .000052 1 1 1
605 119 GRIPAY 174 3 24 .000340 1 1 1
610 120 VALVE 138 0 95 .000206 1 1 1
615 121 VALVE 299 10 80 .000052 2 1 1
620 122 VALVE 160 10 57 .000155 1 1 1
625 123 VALVE 149 10 8 .000299 1 1 1
630 124 FUELCTL 13587 4 100 .001113 1 2 1
635 125 AMP 3891 1 100 .001291 1 2 1
640 126 CONTROL 2440 7 86 .000842 1 1 1
645 127 VALVE 694 10 92 .000136 4 2 1
650 128 VALVE 180 10 75 .000207 3 1 1
655 129 VALVE 208 10 60 .000052 1 1 1
660 130 STARTER 15440 3 77 .003505 1 4 2
665 131 FAN 265 4 49 .001372 2 5 3
670 132 FUELPUMP 11141 0 100 .000441 1 1 1
675 133 PUMP 1393 10 95 .001853 1 3 2
680 134 PUMP 693 10 100 .000113 1 1 1
685 135 PUMP 1526 1 94 .000363 1 1 1
690 136 VALVE 170 5 0 .000040 1 1 1
695 137 VALVE 2349 2 89 .000732 1 1 1
700 138 VALVE 884 10 93 .000144 1 1 1
705 139 VALVE 163 4 79 .000144 1 1 1
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710 140 VALVE 175 7 33 .000031 1 1 1
715 141 VALVE 257 10 43 .000072 1 1 1
720 142 VALVE 297 1 0 .000010 1 1 1
725 143 REGLTR 381 10 98 .000082 1 1 1
730 144 IND 281 0 100 .001597 1 2 1
735 145 CONTROL 252 2 2 .001000 1 1 1
740 146 CONTROL 403 6 10 .002000 1 3 2
745 147 RT 2815 4 27 .003133 1 4 2
750 148 RT 4257 6 11 .008731 1 15 8
755 149 IND 156 5 41 .000268 1 2 1
760 150 RECVR 1543 1 33 .000124 1 2 1
765 151 AMP 486 5 35 .000302 1 1 1
770 152 CTL 120 2 0 .000062 1 1 1
775 153 RECV 1359 5 3 .000348 1 1 1
780 154 RT 1002 4 8 .000528 1 1 1
785 155 MOUNT 229 10 62 .000099 1 1 1
790 156 RT 5302 3 15 .010023 1 12 6
795 157 CONTROL 681 3 10 .001258 1 2 1
800 158 SWEEPGEN 34629 10 34 .006670 1 8 4
805 159 ANTENNA 9408 1 50 .002170 1 3 2
810 160 RT 32000 1 18 .014691 1 10 5
815 161 IND 501 2 89 .002526 1 4 2
820 162 CTLIND 3486 1 45 .002131 1 3 2
825 163 PWRSUP 14924 2 14 .006794 1 4 2
830 164 IND 8756 1 25 .008485 1 10 5
835 165 CTLPNL 1051 1 62 .000599 1 2 1
840 166 PANEL 2327 3 19 .001000 1 1 1
845 167 ANTREC 23727 1 35 .009474 1 8 4
850 168 ANAVCMP 5461 3 18 .003680 1 4 2
855 169 TRANSMTR 12724 3 29 .005412 1 4 2
860 170 RT 2050 2 35 .008041 1 6 3
865 171 SWITCHU 570 2 0 .000001 1 6 3
870 172 COUPLER 319 2 20 .001374 1 2 1
875 173 AMP 1086 3 10 .001772 4 4 2
880 174 IND 747 3 12 .000183 1 1 1
885 175 ANALYZER 3459 6 15 .001428 1 2 1
890 176 RECVR 2320 4 16 .001092 1 2 1
895 177 INTRBOX 1177 1 5 .002000 1 1 1
900 178 BLANKER 3682 3 25 .000344 1 2 1
905 179 CTL 2400 5 46 .000175 1 1 1
910 180 BLANKER 493 1 0 .000072 1 1 1
915 181 CTL 106 3 3 .000938 1 1 1
920 182 RT 3200 3 19 .001965 1 3 2
925 183 TSAPX72 422 4 31 .003000 1 3 2
930 184 SWITCH 74 1 71 .000268 1 3 2
935 185 CTLPNL 622 10 88 .001361 1 2 1
940 186 AMP 1016 1 58 .000341 1 1 1
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945 187 EXTPMON 273 10 25 .003200 1 1 1
950 188 GEN 812 10 79 .000247 1 1 1
955 189 MTRGEN 324 10 33 .001484 1 2 1
960 190 BATCHG 621 7 47 .000546 1 2 1
965 191 PWRSUP 616 10 74 .000155 1 1 1
970 192 BATTERY 663 10 3 .008691 1 12 6
975 193 LIGHT 289 2 2 .002372 2 6 3
980 194 PNLIGHT 1648 3 12 .000474 1 1 1
985 195 IMU 51758 0 63 .008748 1 10 5
990 196 TRANSMTR 280 0 0 .000905 1 1 1
995 197 COMPUTER 10204 2 20 .002320 1 4 2
0001000 198 PILOTDU 28561 0 40 .010165 1 7 4
0001005 199 PROCSR 20733 0 32 .006206 1 7 4
0001010 200 CONVTR 6286 2 33 .001687 1 6 3
0001015 201 ADPTPS 15553 2 48 .003991 1 6 3
0001020 202 CTL 2003 1 50 .000486 1 1 1
0001025 203 PMDU 9204 3 27 .002450 1 9 5
0001030 204 MODULE 2967 0 0 .000864 1 1 1
0001035 205 NWDC 127266 0 43 .008178 1 7 4
0001040 206 IND 231 6 0 .000420 1 3 2
0001045 207 COMP 2575 4 90 .001718 1 3 2
0001050 208 IND 3280 2 98 .001948 1 3 2
0001055 209 COMP 10593 1 27 .009371 1 10 5
0001060 210 TRANSDCR 613 0 100 .003381 1 6 3
0001065 211 IND 3040 0 100 .002087 1 3 2
0001070 212 ACCLMTR 405 0 100 .000701 1 1 1
0001075 213 IND 500 3 92 .001082 1 2 1
0001080 214 IND 1201 0 100 .000237 1 1 1
0001035 215 ACCLMTR 209 6 96 .000012 1 1 1
0001090 216 IND 503 4 83 .002000 1 2 1
0001095 217 SYRALT 1727 5 92 .002000 1 3 2
0001100 218 IND 1388 3 91 .001659 1 2 1
0001105 219 AMP 2286 1 18 .000380 1 1 1
0001110 220 AMP 7082 2 7 .001923 1 4 2
0001115 221 PANFLAY 719 2 0 .00186 1 1 1
0001120 222 TRANSMTR 292 5 100 .002064 1 2 1
0001125 223 GYRO 4920 3 32 .001742 2 3 2
0001130 224 ACCLMTR 663 0 100 .000876 2 3 2
0001135 225 AMP 7334 2 10 .002500 1 5 3
0001140 226 AMP 7214 2 5 .002173 1 5 3
0001145 227 TRANSDCR 2196 0 100 .000929 1 2 1
0001150 228 IND 116 1 100 .000146 1 1 1
0001155 229 TRANSMTR 945 1 85 .000567 1 1 1
0001160 230 IND 659 1 94 .000485 1 1 1
0001165 231 IND 754 0 100 .000780 1 1 1
0001170 232 TRANSMTR 660 0 100 .002939 1 5 3
0001175 233 ACCLOCK 206 24 49 .000873 3 1 1
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0001180 234 IND 1325 0 100 .001936 1 5 3
0001185 235 IND 275 0 100 .001912 1 1 1
0001170 236 IND 773 0 100 .001412 1 3 2
0001195 237 IND 139 10 93 .000300 3 1 1
0001200 238 TRANSMTP 338 7 95 .002043 3 6 3
```

APPENDIX B

ANALYTICAL MODEL FOR MAXIMIZING EXPECTED FILLS

APPENDIX B

ANALYTICAL MODEL FOR MAXIMIZING EXPECTED FILLS

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C GLAZENER/TINDER 76B THESIS
C A7 WRSK LAGRANGIAN FUNCTION
C C(J)= COST OF ITEM J
C QPA(J)= QUANTITY PER AIRCRAFT OF ITEM J
C FR(J)= FAILURE RATE /FLYING HOUR FOR ITEM J
C NAME(J)= ITEM NAME
C QPK(J)= CURRENT QUANTITY OF ITEM J PER KIT
C IRT(J)= REPAIR TIME(DAYS)OF ITEM J
C NRB(J)= % REPAIRED AT BASE LEVEL
C LNB(J)= KIT LINE NUMBERS
C LDT(J)= EXPECTED DEMANDS FOR ITEM J/ 30 DAY PERIOD/ A7 SQUADRON
C STOCK(J)= REVISED QUANTITY(COMPUTED) FOR EACH ITEM J
C P= RECURSIVE CALCULATION FOR STOCK LEVELS
C SD= TOTAL SYSTEM DEMAND RATE
C THETA= CONTROL RATIO
C EFILL= EXPECTED  FILLS
C TCK= TOTAL COST OF KIT
C TC(J)= TOTAL COST OF STOCKING ITEM J
C TSFR= TOTAL SYSTEM FILL RATE
C CMAX,ITER,S,DEL,CP=PROGRAM INDICES AND COUNTERS
 NITMS=238
 CHARACTER NAME*8(238)
 DIMENSION FR(238),IRT(238),NRB(238),LNB(238)
 DIMENSION TC(238)
 REAL LDT(238)
 INTEGER C(238),QPA(238),QPK(238),STOCK(238)
 DIMENSION NQK(238)
 CMAX=0
 SD=0
 DO 10 J=1,NITMS
 READ(05,400,END=44)LNB(J),NAME(J),C(J),IRT(J),NRB(J),
 & FR(J),QPA(J),QPK(J),NQK(J)
 44 LDT(J)=FR(J)*QPA(J)*24*2.5*30
 SD=SD+LDT(J)
 IF(C(J).LE.CMAX) GO TO 10
 CMAX=C(J)
 10 CONTINUE
 PRINT 301,SD
 ITER=1
 THETA=.00002868
 Y=0
 DO 30 I=1,ITER
 THETA=THETA-Y
```

```
EFILL=0
TCK=0
PRINT," ITEM     STOCK     COST "
DO 40 J=1,NITMS
XFILL=0
S=0
P=EXP(-LDT(J))
CP=P
55 DEL=1-CP

IF(DEL.LT.THETA*C(J)) GO TO 60
XFILL=XFILL+DEL
S=S+1
P=P*LDT(J)/S
CP=CP+P
GO TO 55
60 STOCK(J)=S
EFILL=EFILL+XFILL
TC(J)=STOCK(J)*C(J)
TCK=TCK+TC(J)
IF(STOCK(J).EQ.0)GO TO 40
PRINT 101,J,STOCK(J),TC(J)
40 CONTINUE
PRINT 102,TCK
TSFR=EFILL/SD
PRINT 104,TSFR
PRINT 103,THETA
IF(TSFR.GE..96)GO TO 75
30 CONTINUE
400 FORMAT(V)
301 FORMAT(1X,"TOTAL SYSTEM DEMAND RATE IS   ",F10.6)
101 FORMAT(4X,I3,6X,I3,5X,F9.0)
102 FORMAT("THE TOTAL KIT COST FOR THIS MULTIPLIER IS ",F12.0)
103 FORMAT(1X,"THE MULTIPLIER VALUE IS",F12.10)
104 FORMAT(" THE SYSTEM FILL RATE FOR THIS MULTIPLIER IS  ",F6.4)
75 STOP
END
```

APPENDIX C

PROGRAM/EVALUATION OF FILL RATE OF CURRENT A-7D WRSK

APPENDIX C

PROGRAM/EVALUATION OF FILL RATE OF CURRENT A-7D WRSK

```
NITMS=238
CHARACTER NAME*8(238)
DIMENSION FR(238),IRT(238),NRB(238),LNB(238)
DIMENSION TC(238),LNB(238),NQK(238)
LNB HAS PREVIOUSLY BEEN DIMENSIONED
REAL LDT(238)
INTEGER C(238),OPA(238),QPK(238),STOCK(238),S
400 FORMAT(V)
SD=0
EFILL=0
TCK=0
DO 10 J=1,NITMS
READ (05,400,END=46)LNB(J),NAME(J),C(J),IRT(J),NRB(J),
& FR(J),QPA(J),QPK(J),NQK(J)
46 LDT(J)=FR(J)*OPA(J)*30*24*2.5
SD=SD+LDT(J)
TCK=TCK+QPK(J)*C(J)
IF(QPK(J).EQ.0) GO TO 10
XFILL=0
P=EXP(-LDT(J))
CP=P
DO 20 S=1,QPK(J)
XFILL=XFILL+1-CP
P=P*LDT(J)/S
CP=CP+P
20 CONTINUE
EFILL=EFILL+XFILL
CP=XFILL/LDT(J)
PRINT 65,J,LDT(J),CP,XFILL,QPK(J)
10 CONTINUE
TSFR=EFILL/SD
PRINT 50,TSFR
PRINT 60,TCK
50 FORMAT( "THE SYSTEM FILL RATE IS ", F6.4)
60 FORMAT(" THE TOTAL COST FOR THIS KIT IS ",F12.2)
65 FORMAT(I3,3X,F7.4,3X,F7.5,3X,F8.5,3X,I3)
70 STOP
END
```

Item #	Expected 30-Day Demand	Item Fill Rate	Expected Fills	Quantity in Kit
1	0.1224	0.99993	0.12239	3
2	0.2322	1.00000	0.23220	5
3	0.2538	1.00000	0.25380	6
4	0.0270	0.98662	0.02664	1
5	0.5508	1.00000	0.55080	13
6	0.6570	1.00000	0.65700	15
7	0.7686	1.00000	0.76860	14
8	0.1062	0.99822	0.10601	2
9	0.7038	1.00000	0.70380	13
10	0.3636	1.00000	0.36360	8
11	2.5758	1.00000	2.57580	14
12	0.8748	1.00000	0.87480	8
13	2.1348	0.99978	2.13432	8
14	0.3762	0.99987	0.37615	4
15	0.2556	1.00000	0.25560	6
16	0.8334	0.99969	0.83314	5
17	0.1062	0.99995	0.10620	3
18	17.6256	0.17021	3.00000	3
19	2.3580	0.67332	1.58769	2
20	0.2196	0.89781	0.19716	1
21	0.1476	0.92970	0.13722	1
22	3.4146	0.72775	2.48498	3
23	7.2720	0.53641	3.90080	4
24	0.6318	0.74132	0.46837	1
25	16.2000	0.24691	3.99991	4
26	2.0034	0.72878	1.46004	2
27	0.2970	0.86517	0.25696	1
28	0.9270	0.65185	0.60426	1
29	1.2240	0.57676	0.70595	1
30	0.0018	0.99910	0.00180	1
31	11.3544	0.52429	5.95301	6
32	0.2412	0.88854	0.21432	1
33	57.6000	0.41667	24.00000	24
34	0.0036	0.99820	0.00359	1
35	1.0584	0.61696	0.65299	1
36	5.6808	0.50978	2.89598	3
37	0.0936	0.95463	0.08935	1

38	0.0936	0.95463	0.08935	1
39	0.2232	0.89626	0.20005	1
40	3.0132	0.31557	0.95087	1
41	0.5382	0.77332	0.41620	1
42	0.7974	0.68912	0.54950	1
43	0.6120	0.74793	0.45773	1
44	0.0180	0.99105	0.01784	1
45	0.0378	0.98134	0.03709	1
46	0.0378	0.98134	0.03709	1
47	1.2060	0.58093	0.70061	1
48	1.6380	0.49184	0.80563	1
49	3.6000	0.70673	2.54424	3
50	0.2592	0.88091	0.22833	1
51	0.3348	0.84982	0.28452	1
52	6.4800	0.45422	2.94332	3
53	0.1854	0.91277	0.16923	1
54	1.5192	0.51416	0.78111	1
55	0.5202	0.96499	0.50199	2
56	0.1476	0.92970	0.13722	1
57	0.3708	0.83554	0.30982	1
58	0.2232	0.89626	0.20005	1
59	1.4976	0.51839	0.77633	1
60	0.4266	0.81405	0.34728	1
61	0.7056	0.94096	0.66394	2
62	0.7236	0.71171	0.51500	1
63	1.1808	0.58686	0.69297	1
64	1.0656	0.61513	0.65548	1
65	0.4752	0.79596	0.37824	1
66	0.2952	0.86591	0.25562	1
67	1.1160	0.60252	0.67241	1
68	0.1854	0.91277	0.16923	1
69	1.4400	0.52991	0.76307	1
70	0.4644	0.79993	0.37149	1
71	0.3150	0.85781	0.27021	1
72	11.0970	0.61907	6.86985	7
73	0.6318	0.74132	0.46837	1
74	0.6318	0.74132	0.46837	1
75	0.1278	0.93874	0.11997	1
76	0.2232	0.89626	0.20005	1
77	0.2232	0.89626	0.20005	1
78	0.6498	0.73538	0.47785	1
79	5.1984	0.37708	1.96023	2
80	0.8730	0.66701	0.58230	1
81	1.6650	0.48697	0.81081	1

82	0.4824	0.79332	0.38270	1
83	2.7864	0.33676	0.93836	1
84	0.2412	0.88854	0.21432	1
85	0.1116	0.94622	0.10560	1
86	0.3348	0.84982	0.28452	1
87	0.1476	0.92970	0.13722	1
88	0.0360	0.98221	0.03536	1
89	1.0026	0.63143	0.63308	1
90	0.2232	0.89626	0.20005	1
91	5.0400	0.19713	0.99353	1
92	2.7864	0.33676	0.93836	1
93	0.2034	0.90486	0.18405	1
94	0.5184	0.78034	0.40453	1
95	0.1296	0.93791	0.12155	1
96	0.0180	0.99105	0.01784	1
97	0.9270	0.65185	0.60426	1
98	0.0720	0.96485	0.06947	1
99	1.4472	0.52845	0.76477	1
100	0.8532	0.67270	0.57395	1
101	1.9296	0.44299	0.85479	1
102	6.4332	0.81058	5.21464	6
103	5.5116	0.78487	4.32589	5
104	0.5004	0.78679	0.39371	1
105	0.7056	0.71739	0.50619	1
106	0.4266	0.97538	0.41610	2
107	0.7236	0.71171	0.51500	1
108	0.4824	0.79332	0.38270	1
109	0.4644	0.79993	0.37149	1
110	2.0556	0.72038	1.48082	2
111	0.3150	0.85781	0.27021	1
112	0.5904	0.99993	0.59036	5
113	22.0500	0.13605	3.00000	3
114	0.1476	0.92970	0.13722	1
115	0.5004	0.78679	0.39371	1
116	0.4392	0.80931	0.35545	1
117	0.8910	0.66190	0.58975	1
118	0.0936	0.95463	0.08935	1

119	0.6120	0.74793	0.45773	1
120	0.3708	0.83554	0.30982	1
121	0.1872	0.91198	0.17072	1
122	0.2790	0.87262	0.24346	1
123	0.5382	0.77332	0.41620	1
124	2.0034	0.72878	1.46004	2
125	2.3238	0.67850	1.57670	2
126	1.5156	0.51486	0.78032	1
127	0.9792	0.89969	0.88098	2
128	1.1178	0.60208	0.67300	1
129	0.0936	0.95463	0.08935	1
130	6.3090	0.60385	3.80967	4
131	4.9392	0.82919	4.09556	5
132	0.7938	0.69019	0.54788	1
133	3.3354	0.73685	2.45769	3
134	0.2034	0.90486	0.18405	1
135	0.6534	0.73420	0.47973	1
136	0.0720	0.96485	0.06947	1
137	1.3176	0.55572	0.73222	1
138	0.2592	0.88091	0.22833	1
139	0.2592	0.88091	0.22833	1
140	0.0558	0.97261	0.05427	1
141	0.1296	0.93791	0.12155	1
142	0.0180	0.99105	0.01784	1
143	0.1476	0.92970	0.13722	1
144	2.8746	0.60004	1.72488	2
145	1.8000	0.46372	0.83470	1
146	3.6000	0.70673	2.54424	3
147	5.6394	0.65722	3.70631	4
148	15.7158	0.87625	13.77101	15
149	0.4824	0.96935	0.46761	2
150	0.2232	0.99256	0.22154	2
151	0.5436	0.77142	0.41935	1
152	0.1116	0.94622	0.10560	1
153	0.6264	0.74312	0.46549	1
154	0.9504	0.64543	0.61341	1
155	0.1782	0.91596	0.16322	1
156	18.0414	0.65905	11.89019	12
157	2.2644	0.68758	1.55696	2
158	12.0060	0.65254	7.83437	8
159	3.9060	0.67306	2.62896	3
160	26.4438	0.37816	9.99988	10
161	4.5468	0.75388	3.42775	4
162	3.8358	0.68066	2.61088	3
163	12.2292	0.32689	3.99758	4
164	15.2730	0.64696	9.88107	10

165	1.0782	0.88367	0.95277	2
166	1.8000	0.46372	0.83470	1
167	17.0532	0.46864	7.99188	8
168	6.6240	0.58057	3.84569	4
169	9.7416	0.40891	3.98341	4
170	14.4738	0.41415	5.99432	6
171	0.0018	1.00002	0.00180	6
172	2.4732	0.65617	1.62284	2
173	12.7584	0.31339	3.99841	4
174	0.3294	0.85199	0.28064	1
175	2.5704	0.64206	1.65034	2
176	1.9656	0.73491	1.44453	2
177	3.6000	0.27019	0.97268	1
178	0.6192	0.95266	0.58989	2
179	0.3150	0.85781	0.27021	1
180	0.1296	0.93791	0.12155	1
181	1.6884	0.48282	0.81519	1
182	3.5370	0.71383	2.52481	3
183	5.4000	0.53182	2.87182	3
184	0.4824	0.99648	0.48070	3
185	2.4498	0.65962	1.61593	2
186	0.6138	0.74733	0.45871	1
187	5.7600	0.17306	0.99685	1
188	0.4446	0.80729	0.35892	1
189	2.6712	0.62777	1.67690	2
190	0.9828	0.89912	0.88365	2
191	0.2790	0.87262	0.24346	1
192	15.6438	0.74572	11.66592	12
193	8.5392	0.67223	5.74032	6
194	0.8532	0.67270	0.57395	1
195	15.7464	0.62917	9.90712	10
196	1.6290	0.49348	0.80387	1
197	4.1760	0.78828	3.29184	4
198	18.2970	0.38251	6.99881	7
199	11.1708	0.61547	6.87526	7
200	3.0366	0.98227	2.98276	6
201	7.1838	0.76002	5.45984	6
202	0.8748	0.66650	0.58305	1
203	4.4100	0.99458	4.38612	9
204	1.5552	0.50724	0.78885	1
205	14.7204	0.47459	6.98613	7
206	0.7560	0.98843	0.74725	3
207	3.4524	0.72343	2.49758	3
208	3.5064	0.71729	2.51512	3
209	16.8678	0.58984	9.94930	10
210	6.0858	0.83373	5.07391	6

211	3.7566	0.68933	2.58953	3
212	1.2618	0.56812	0.71686	1
213	1.9476	0.73784	1.43701	2
214	0.4266	0.81405	0.34728	1
215	0.0216	0.98928	0.02137	1
216	3.6000	0.51305	1.84699	2
217	3.6000	0.70673	2.54424	3
218	2.9862	0.58546	1.74830	2
219	0.6840	0.72428	0.49541	1
220	3.4614	0.85386	2.95556	4
221	3.3480	0.28819	0.96485	1
222	3.7152	0.50087	1.86083	2
223	6.2712	0.46777	2.93346	3
224	3.1536	0.75795	2.39028	3
225	4.5000	0.86218	3.87981	5
226	3.9114	0.90331	3.53321	5
227	1.6704	0.78384	1.30933	2
228	0.2628	0.87939	0.23110	1
229	1.0206	0.62671	0.63962	1
230	0.8730	0.66701	0.58230	1
231	1.4040	0.53731	0.75439	1
232	5.2884	0.80224	4.24255	5
233	4.7142	0.21022	0.99103	1
234	3.4848	0.92974	3.23994	5
235	3.4416	0.28126	0.96799	1
236	2.5416	0.82987	2.10921	3
237	1.6200	0.49512	0.80210	1
238	11.0322	0.53863	5.94223	6

THE SYSTEM FILL RATE IS 0.5550
THE TOTAL COST FOR THIS KIT IS 4153549.00

APPENDIX D

EXPECTED FILLS MAXIMIZED FOR 30 DAYS--KIT COMPOSITION

APPENDIX D

EXPECTED FILLS MAXIMIZED FOR 30 DAYS--KIT COMPOSITION

TOTAL SYSTEM DEMAND RATE IS 736.137016

ITEM	STOCK	COST
1	1	1206.
3	1	1041.
4	1	185.
5	3	744.
6	3	495.
7	3	3423.
8	1	313.
9	3	2832.
10	2	3626.
11	5	12775.
12	4	1452.
13	4	9664.
14	2	618.
15	1	990.
16	2	12202.
17	1	493.
18	26	29822.
19	1	27573.
20	2	478.
21	1	2780.
22	6	13164.
23	13	11349.
24	3	1470.
25	27	6885.
26	6	1104.
27	1	3973.
28	2	7502.
29	3	4836.
31	20	8740.
32	1	1597.
33	72	71640.
35	3	5043.
36	10	20610.
37	1	274.
38	1	274.
39	2	166.
40	9	747.
41	3	249.
42	4	360.
43	4	344.
44	1	254.
45	1	226.
46	1	269.
47	4	1236.
48	5	1405.

49	7	9695.
50	2	1476.
51	2	1474.
52	14	2100.
53	1	2471.
54	6	732.
55	1	13818.
56	2	370.
57	2	568.
58	2	862.
59	6	834.
60	2	784.
61	2	3266.
62	3	3495.
63	4	2284.
64	3	5418.
65	2	1176.
66	2	1100.
67	3	3945.
68	1	915.
69	4	6212.
70	2	2720.
72	21	3066.
73	2	5650.
74	2	6602.
75	1	1644.
76	1	1707.
77	1	1588.
78	3	1662.
79	8	33568.
80	2	7584.
81	4	5316.
82	3	474.
83	6	8448.
84	1	1515.
85	1	1572.
86	1	1684.
87	1	1684.
88	1	76.
89	3	2139.
90	2	324.
91	12	1056.
92	8	736.
93	2	178.
94	3	321.

95	2	168.
96	1	151.
97	3	1806.
98	1	201.
99	6	546.
100	4	476.
101	7	623.
102	13	6097.
103	9	22158.
104	3	1410.
105	3	744.
106	2	1576.
107	3	1221.
108	2	970.
109	2	1328.
110	5	6740.
111	2	420.
112	3	1005.
113	35	5460.
114	1	1163.
115	2	3048.
116	2	1590.
117	3	2835.
118	1	171.
119	3	522.
120	3	414.
121	2	598.
122	2	320.
123	3	447.
124	2	27174.
125	4	15564.
126	3	7320.
127	3	2082.
128	5	900.
129	1	208.
130	7	108080.
131	11	2915.
132	1	11141.
133	7	9751.
134	1	693.
135	2	3052.
136	1	170.
137	3	7044.
138	2	1768.
139	2	326.

140	1	175.
141	2	514.
142	1	297.
143	1	381.
144	8	2248.
145	6	1512.
146	9	3627.
147	9	25335.
148	20	85140.
149	3	468.
150	1	1543.
151	3	1458.
152	2	240.
153	2	2718.
154	3	3006.
155	2	458.
156	22	116644.
157	6	4086.
158	4	138516.
159	5	47040.
160	19	608000.
161	10	5010.
162	6	20916.
163	13	194012.
164	18	157608.
165	3	3153.
166	4	9308.
167	15	355905.
168	9	49149.
169	11	139964.
170	21	43050.
172	7	2233.
173	20	21720.
174	2	1494.
175	5	17295.
176	4	9280.
177	7	8239.
178	2	7364.
179	1	2400.
180	1	493.
181	6	636.

182	6	19200.
183	11	4642.
184	3	222.
185	6	3732.
186	2	2032.
187	12	3276.
188	2	1624.
189	7	2268.
190	4	2484.
191	2	1232.
192	24	15912.
193	16	4624.
194	3	4944.
196	5	1400.
197	5	51020.
198	14	399854.
199	10	207330.
200	5	31430.
201	7	108871.
202	3	6009.
203	6	55224.
204	3	8901.
206	4	924.
207	6	15450.
208	6	19680.
209	19	201267.
210	12	7356.
211	6	18240.
212	4	1940.
213	6	3000.
214	2	2402.
215	1	209.
216	8	4024.
217	7	12089.
218	6	8328.
219	2	4572.
220	5	35410.
221	8	5752.
222	9	2538.
223	9	44280.

224	7	4641.
225	6	44004.
226	5	36070.
227	4	8784.
228	2	232.
229	3	2835.
230	3	1977.
231	4	3016.
232	11	7260.
233	11	2266.
234	7	9275.
235	9	2475.
236	6	4638.
237	6	834.
238	19	6422.

THE TOTAL KIT COST FOR THIS MULTIPLIER IS 4244190.
THE SYSTEM FILL RATE FOR THIS MULTIPLIER IS 0.9028
THE MULTIPLIER VALUE IS 0.00002868

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